ADVANCED FUEL CYCLE (AFC) FIVE-YEAR PROGRAM PLAN

by

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Of the issues that must be addressed to enable a future expansion in the use of nuclear energy in the United States and worldwide, none is more important or more challenging than that of dealing effectively with spent nuclear fuel. While nuclear plants produce far less waste by volume than any comparable energy-producing or industrial activity, the unique nature of spent fuel requires that long-term planning for the use of nuclear power include consideration of the eventual disposition of this waste product. Disposal of this material, which is highly radioactive for hundreds of thousands of years, presents a wide range of social, political, regulatory, and technical issues. In combination with the current once-through fuel cycle, the potential growth of nuclear power has been limited.

Over the last three years, the DOE, its laboratories, and university and private industry partners have worked with the international research community to explore the potential of advanced nuclear technologies for dramatically reducing the difficulty of disposing of spent fuel from nuclear power plants. This research is designed to reduce the volume and toxicity of the nuclear waste.

The AFC Program mission is to enable the future of nuclear power by addressing the spent nuclear fuel problem. Development of advanced nuclear power is essential to address energy security, environmental, and future economic concerns, and the current once-through fuel cycle is recognized as limiting the growth of nuclear power to address these concerns.

The primary goals of the AFC Program are to:

- Develop and implement advanced fuel cycle technologies to significantly reduce the long-term cost of geological disposal of commercial spent nuclear fuel.
- Develop methods to reclaim the energy value from highly toxic spent fuel while providing for their destruction.

The AFC Program is executed as a multiphased program consisting of two elements executed in parallel as part of an integrated research effort:

- AFC Program Series One: This component of the program addresses the intermediate-term issues associated with spent nuclear fuel, primarily by reducing the volume and heat generation of material requiring geologic disposal. This will optimize utilization of the nation's first repository and reduce or eliminate the need for additional repositories. Series One includes creating proliferation-resistant processes and fuels to enable the destruction of significant quantities of

plutonium in light water reactors or high temperature gas-cooled reactors by the middle of the next decade.

- AFC Program Series Two: This component of the program addresses the longer-term issues associated with spent nuclear fuel. Specifically, this effort will develop fuel cycle technologies to greatly reduce the long-term radiotoxicity and heat load of high-level waste sent to a geologic repository through support of the development of Generation IV program reactors and possible accelerator systems.

The Series One and Series Two activities are managed as part of an integrated program. For example, treatment technologies emerging from Series One may prove to be invaluable front-end steps for more advanced processes targeted in Series Two. Integration of these two elements is essential to the success of the overall effort.

The main priority of the AFC Program is to provide timely resolution of issues related to spent nuclear fuel disposition, including reducing the cost of the proposed first repository and delaying or eliminating the need for a second repository. This will be achieved through separating long-lived, highly toxic elements, reducing high-level waste volumes and the toxicity of spent nuclear fuel, and reducing the long-term heat generation. A second priority is to address energy and economic security through enabling the proliferation-resistant recovery of the energy contained in spent fuel and supporting the future operation of Generation IV nuclear energy systems. Finally, the program will address nonproliferation concerns by reducing long-term inventories of plutonium in spent fuel and reducing its long-term proliferation threat.

The Office of Nuclear Energy, Science and Technology (NE) is responsible for leading the Federal government s investment in nuclear science and technology. The AFC Program is closely linked to another NE Program, the Generation IV Nuclear Energy Systems Program (Generation IV). Generation IV is an international initiative for identifying, developing, and demonstrating one or more new nuclear energy systems offering advantages in the areas of economics, safety and reliability, and sustainability, with a deployment target of 2030. By integrating the AFC Program and Generation IV programs through the use of systems analysis, NE has established a structure, which will facilitate the coordination of both programs to support a unified research and development effort. Within this structure, the AFC Program has been organized to maximize and leverage technical functional expertise while enhancing communication between program participants through systems analysis and technical integration.

The AFC and Generation IV programs have an integrated management structure, sharing a common Systems Integration and Analysis function. Roles and responsibilities for key AFC Program functions are shared among the headquarters organizations of NE, Technical Integration, Systems Integration and Analysis, and the National Technical Directors for each of the three elements of the AFC Program — Fuels, Separations, and Transmutation. Product Teams are established, as needed, to address crosscutting issues throughout the functional program elements of the AFC and the Generation IV Programs.

The Series One element of the AFC Program addresses specific intermediate term issues facing nuclear power. These issues are:

- reducing high-level waste volumes,
- increasing the capacity of the planned geologic repository,
- reducing the technical need for a second repository,
- reducing long-term inventories of plutonium in spent nuclear fuel, and
- enabling recovery of the energy contained in spent nuclear fuel.

To achieve this goal, Series One will initiate operations of a Spent Fuel Treatment Facility and a Proliferation Resistant Fuel Fabrication Facility by 2015 and 2018, respectively. In the first five years, the technology program is structured to analyze and develop options for the technology selections in FY2007, as well as provide design support to the facility design activities. After these selections, the technical program provides more focused support to the final design, construction, startup, and initial operations of the facilities. Series One transmutation activities for commercial plutonium and other minor actinides are considered an implicit part of the fuel development activity, and consequently, no Series One transmutation activities are indicated.

The Series Two element of the AFC Program addresses specific long-term issues facing nuclear power. These are:

- reducing the toxicity and longevity of spent nuclear fuel,
- reducing the long-term heat generation of spent nuclear fuel,
- providing a sustainable fuel source for nuclear energy, and
- supporting the future operation of Generation IV nuclear energy systems.

To achieve these objectives, we must begin deploying advanced reactors that use sustainable, proliferation resistant fuel cycles. This requires a Generation IV Fuel Fabrication Facility to be in operation by 2022 to provide fuels for the performance testing and deployment of Generation IV reactor systems. In addition, Series Two will develop an approach for the transmutation of unburned plutonium and minor actinides from the Series One Spent Fuel Treatment Facility through Generation IV reactors and, possibly, ADS.

One element of Series Two transmutation activities is focused on Accelerator Driven Systems (ADS). Many countries are considering ADS systems as a viable approach to transmutation, because such systems may be capable of destroying all long-lived radioactive isotopes without making plutonium. In FY2007, there is also a selection of transmutation technologies. Regardless of the path forward chosen at that point, the information derived from the work on accelerator systems should facilitate more efficient and economic designs in later transmutation work.